

We claim:

1. A composite electrolyte for a rechargeable lithium battery comprising:
an inert, first, porous, laminate layer of a first polymer, having a first
multiplicity of pores including walls, and two major faces, and having an
adherent, solid, second layer of a second polymer deposited on at least one of
said major faces, said adherent, solid, second polymer layer containing a first
lithium compound having dissociable lithium ions, wherein said adherent, solid,
second polymer layer partially fills one portion of said first multiplicity of pores of
said inert, first, porous laminate layer, thereby providing a composite, porous,
polymer structure of at least two polymer layers, having a second portion of said
first multiplicity of pores unfilled, and wherein said unfilled second portion of said
pores of said composite, porous, polymer structure is impregnated with an
organic liquid containing a second lithium compound having dissociable lithium
ions, and wherein said inert, first, porous laminate layer is comprised of a
second multiplicity of porous sub-layers, and at least two of said second
multiplicity of porous sub-layers have different melting temperatures.
2. A composite electrolyte for a rechargeable lithium battery as claimed in
claim 1, wherein said inert, first, porous laminate layer comprises within said
second multiplicity of porous sub-layers, one porous sub-layer sandwiched
between at least two other sub-layers, said one sandwiched porous sub-layer
having a significantly lower melting temperature than the other sub-layers.
3. A composite electrolyte for a rechargeable lithium battery as claimed in
claim 1 or 2, wherein said first polymer of said inert, first, porous laminate layer
is chemically different from said adherent, solid, second polymer deposited on at
least one of said major faces of said inert, first, porous laminate layer.
4. A composite electrolyte for a rechargeable lithium battery as claimed in
claim 1 or 2, wherein each porous sub-layer of the second multiplicity of sub-
layers comprised in said inert, first, porous laminate layer, is made of a
polymeric compound selected from the group consisting of polyethylene,
polypropylene, another long chained polyalkene, and a blended mixture of
polyalkenes.
5. A composite electrolyte for a rechargeable lithium battery as claimed in
claim 2, wherein said one sandwiched porous sub-layer in said second

multiplicity of sub-layers comprised in said inert, first, porous laminate layer is made of a polymeric compound having melting temperature at least 20°C below the melting temperature of the polymeric compounds of each of said other porous sub-layers of said second multiplicity of porous sub-layers.

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6. A composite electrolyte for a rechargeable lithium battery as claimed in claim 1, wherein said solid, second polymer is selected from the group consisting of polyethylene oxide, polytetrafluoroethylene (PTFE), and polyvinylidene fluoride copolymer.

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7. A composite electrolyte for a rechargeable lithium battery as claimed in claim 1, wherein said first lithium compound having dissociable lithium ions is selected from the group consisting of lithium triflate, lithium borohexafluoride, lithium phosphohexafluoride, lithium arsenofluoride and lithium perchlorate.

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8. A composite electrolyte for a rechargeable lithium battery as claimed in claim 1, wherein said second lithium compound having dissociable lithium ions dissolved in said organic liquid, is selected from the group consisting of lithium triflate, lithium borohexafluoride, lithium phospho-hexafluoride, lithium arsenofluoride and lithium perchlorate.

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9. A composite electrolyte for a rechargeable lithium battery as claimed in claim 1, wherein said organic liquid is selected from the group consisting of ethylene carbonate, di-methyl carbonate, di-ethyl carbonate, methyl-ethyl carbonate, propylene carbonate, and mixtures thereof.

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10. A composite electrolyte for a rechargeable lithium battery as claimed in claim 1, wherein said first lithium compound having dissociable lithium ions is the same as said second lithium compound.

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11. A composite electrolyte for a rechargeable lithium battery as claimed in claim 6, wherein said adherent, solid, second polymer layer is deposited on at least one of the major faces of said inert, first, porous laminate layer, and said deposited adherent second polymer layer partially fills one portion of said first multiplicity of pores, by one of the methods selected from the group: electrophoresis, vapour deposition, coating of a suspension of said second polymer, heat-compression coating with a lithium compound containing binder compound, and immersion of said inert, first, porous laminate layer comprised of

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said second multiplicity of sub-layers of said first polymer, in an emulsion of said second polymer.

5 12. A composite electrolyte for a rechargeable lithium battery as claimed in claim 1, wherein said first multiplicity of pores of said inert, first, porous laminate layer is partially filled by at least partially coating said walls of said first multiplicity of pores with said adherent, solid, second layer of the second polymer.

10 13. A composite electrolyte for a rechargeable lithium battery as claimed in claim 1, wherein said composite, porous, polymer structure is formed of a third multiplicity of polymer layers and sub-layers, and wherein the first and last layers thereof are adherent, solid, layers of said second polymer deposited on said major faces of said inert, first, porous laminate layer comprised of said second
15 multiplicity of porous sub-layers.

14. A rechargeable lithium battery comprising:

a positive electrode;

a negative electrode; and

20 a composite electrolyte placed between said negative and positive electrodes, comprising an inert, first, porous laminate layer of a first polymer, having a first multiplicity of pores including walls, and two major faces, and having an adherent, solid, second layer of a second polymer deposited on at least one of said major faces, said adherent, solid, second polymer layer
25 containing a first lithium compound having dissociable lithium ions, wherein said adherent, solid, second polymer layer partially fills one portion of said first multiplicity of pores of said inert, first, porous laminate layer, thereby providing a composite, porous, polymer structure of at least two polymer layers having a second portion of said first multiplicity of pores unfilled, and wherein said unfilled
30 second portion of said pores of said composite, porous, polymer structure is impregnated with an organic liquid containing a second lithium compound having dissociable lithium ions, and wherein said inert, first, porous laminate layer is comprised of a second multiplicity of porous sub-layers, and at least two of said second multiplicity of porous sub-layers have different melting
35 temperatures.

15. A rechargeable lithium battery having a composite electrolyte as claimed in claim 14, wherein said inert, first, porous laminate layer comprises within said

second multiplicity of porous sub-layers, one porous sub-layer sandwiched between at least two other sub-layers, said one sandwiched porous sub-layer having a significantly lower melting temperature than the other sub-layers.

- 5 16. A rechargeable lithium battery having a composite electrolyte as claimed in claim 14 or 15, wherein said first multiplicity of pores of said inert, first, porous laminate layer is partially filled by at least partially coating said walls of said first multiplicity of pores with said adherent, solid, second layer of the second polymer.
- 10 17. A rechargeable lithium battery having a composite electrolyte as claimed in claim 14 or 15, wherein said first polymer of said inert, first, porous laminate is chemically different from said second polymer deposited on at least one of said major faces of said inert, first, porous laminate layer.
- 15 18. A rechargeable lithium battery having a composite electrolyte as claimed in claim 14 or 15, wherein said first polymer of said inert, first, porous laminate layer is selected from the group consisting of polyethylene, polypropylene, another long chain polyalkene and a blended mixture of polyalkenes.
- 20 19. A rechargeable lithium battery having a composite electrolyte as claimed in claim 14, wherein each porous sub-layer of said second multiplicity of porous sub-layers of the inert, first, porous laminate layer is comprised of a polymeric compounds selected from the group consisting of polyethylene, polypropylene, another long chain polyalkene and a blended mixture of polyalkenes.
- 25 20. A rechargeable lithium battery having a composite electrolyte as claimed in claim 18, wherein at least one of said second multiplicity of porous sub-layers is made of a polymeric compound having melting temperature at least 20°C below the melting temperature of the polymeric compound of each other sub-porous layer comprised in said second multiplicity of porous sub-layers of said inert, first, porous laminate layer.
- 30 21. A rechargeable lithium battery having a composite electrolyte as claimed in claim 14, wherein said second polymer is selected from the group consisting of polyethylene oxide, polytetrafluoroethylene (PTFE), and polyvinylidene fluoride copolymer.
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22. A rechargeable lithium battery having a composite electrolyte as claimed in claim 14, wherein said first lithium compound having dissociable lithium ions is selected from the group consisting of lithium triflate, lithium borohexafluoride, lithium phosphohexafluoride, lithium arsenofluoride and lithium perchlorate.

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23. A rechargeable lithium battery having a composite electrolyte as claimed in claim 14, wherein said second lithium compound having dissociable lithium ions dissolved in said organic liquid, is selected from the group consisting of lithium triflate, lithium borohexafluoride, lithium phospho-hexafluoride, lithium arsenofluoride and lithium perchlorate.

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24. A rechargeable lithium battery having a composite electrolyte as claimed in claim 14, wherein said first lithium compound having dissociable lithium ions is the same as said second lithium compound.

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